



# Operational Status of MINOS+

Fermilab Operations Review

8 February, 2013

Rob Plunkett, PPD



# Introduction



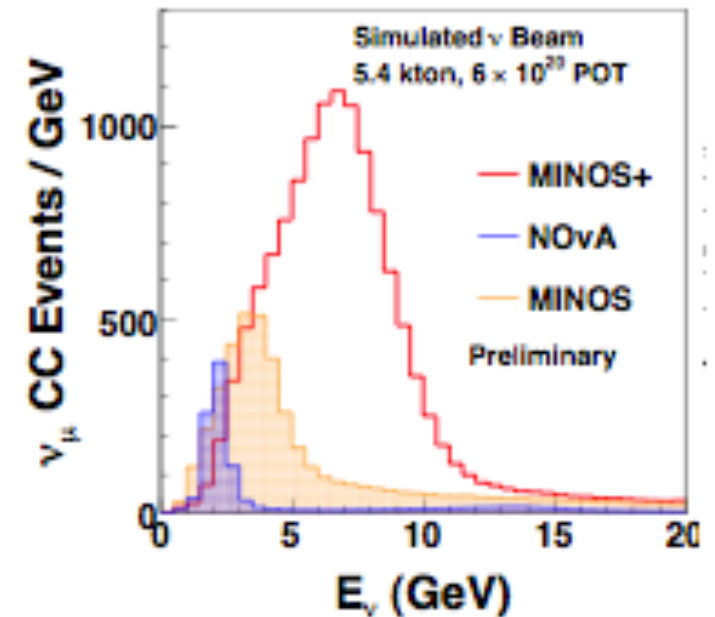
- MINOS+ collaboration
- Readiness of near and far detectors
- Offline preparations
- Computing resources
- Discussion



# Overview

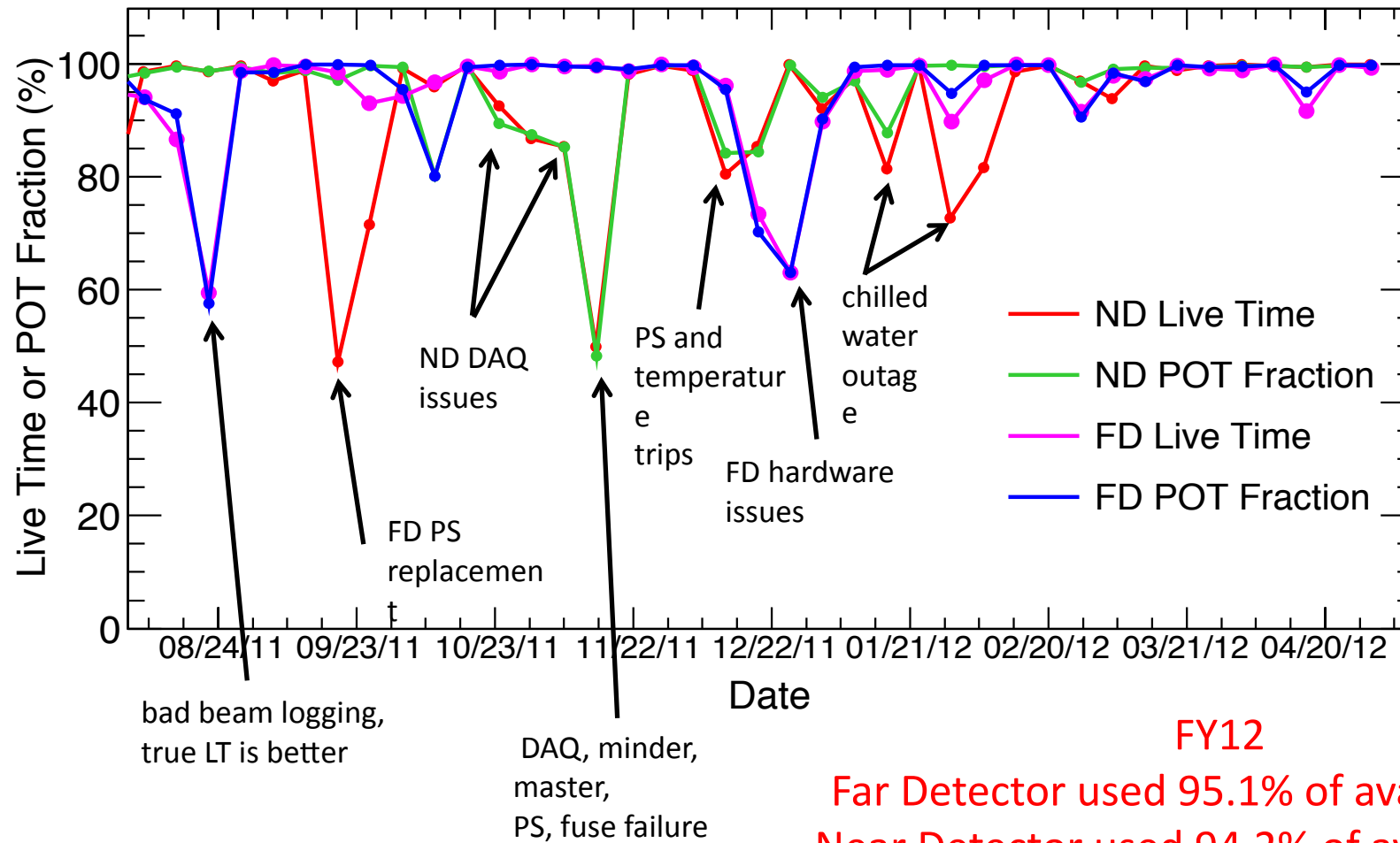


- MINOS+ is continuation of successful experiment which has run for 7 years.
- Robust, scintillator-based detector.
- Main differences
  - Medium Energy beam gives larger rate
  - Smaller collaboration (due to strong FNAL program!)
  - Upgraded readout for near (and possibly far)





# Operational History





**M I N O S**

# MINOS+ Collaboration



## **University of Athens**

G. Tzanakos

## **Brookhaven**

M. Bishai, M.V. Diwan, Z. Isvan

## **Caltech**

R.B. Patterson

## **University of Cambridge**

A. Blake, M.A. Thomson

## **University of Cincinnati**

A. Aurisano\*, A. Sousa

## **Fermilab**

P. Adamson, S. Childress, S. Hahn, R. Hatcher, C. James, A. Kreymer, S. Moed Sher, R.B. Pahlka, R.K. Plunkett, N. Poonthottathil\*, B. Rebel, R. Sharma, D. Torretta

## **Federal University of Goias**

C.M. Castromonte\*, R.A. Gomes, M.M. Medeiros, S.C. Tognini\*

## **Harvard University**

G.J. Feldman, R. Toner

## **Holy Cross College**

M.V. Frohne

## **University of Houston**

L. Whitehead

## **Iowa State**

I. Anghel, M.C. Sanchez

## **University College London**

A. Holin, R.J. Nichol, J. O'Connor\*, A. Perch\*, A. Radovic, J. Thomas, L.H. Whitehead\*

## **Los Alamos**

G. Mills, Z. Pavlovic

## **University of Manchester**

J.J. Evans, A. Timmons\*

## **University of Minnesota, Twin Cities**

D.Cronin-Hennessy, M.L. Marshak, J.R. Meier, W.H. Miller, J.A. Nowak, G. Pawloski, A. Schreckenberger, (D. Osterholm and D. Saranen – Ops, P. Litchfield)

## **University of Minnesota Duluth**

R. Gran, A. Habig

## **Otterbein University**

N. Tagg

## **University of Oxford**

G. Barr, J.K. de Jong, A. Weber

## **University of Pittsburgh**

C. McGivern\*, D. Naples

## **University of South Carolina**

S.R. Mishra, C. Rosenfeld, X. Tian\*

## **Stanford University**

X. Qiu, S.G. Wojcicki

## **University of Sussex**

J. Hartnell

## **University of Texas at Austin**

S.V. Cao, J. Huang\*, K. Lang, R. Mehdiyev, J.L. Ritchie

## **Tufts University**

J.A.B. Coelho, H.R. Gallagher, W.A. Mann, N. Mayer

## **UNICAMP - University of Campinas**

C.O. Escobar

## **USP - University of Sao Paulo**

P. Gouffon

## **University of Warsaw**

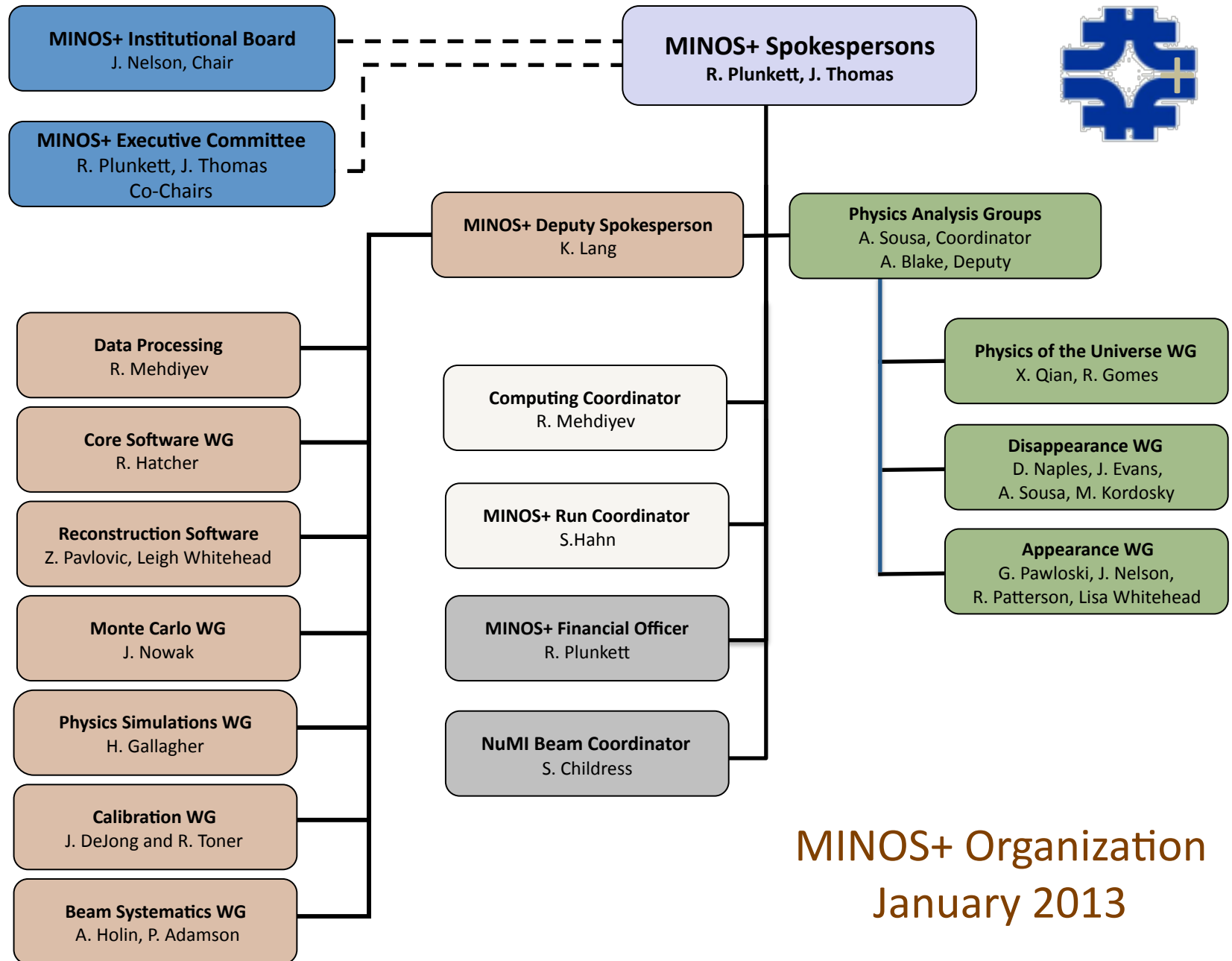
K. Grzelak

## **William & Mary**

A.V. Devan, M. Kordosky, J.K. Nelson, P. Vahle

**28 Institutions**  
**74 Collaborators**  
**~35 FTE**

**Negotiations with Indian  
institutions ongoing**



MINOS+ Organization  
January 2013



# Collaboration Service Task Status



- Service tasks required for collab. membership.
- Coordinated by Deputy Spokesperson, visible by open web page.
- Current status: 32 defined jobs, 28 filled (88%), 2 vacant, 2 need transition.

- **Beam and Data Quality Monitoring (Andy B. and Andy P. )**

- 1) **DST production**

- Making plots of statistical assessment on events / POT or time. Famous energy spectra vs. time, etc...

- Person assigned: Andy P.

- 2) **Modernize Data Quality Monitoring**

- Migrate the data quality code over to using the DSTs, and make the DSTs part of batch processing.

- Person assigned: Ashley T.

- **Calibration WG (convener: Jeff dJ.)**

- 1) **Strip to Strip Calibration**

- An intra-detector calibration which normalizes the response of each strip.

- Person assigned: Ioana A.

- 2) **Linearity**

- A calibration which uses Light Injection to measure the non-linearity of the PMT response.

- Person assigned: Nathaniel T.

- 3) **Gains**

- Uses the Light Injection system to measure the gains of the PMT in units of ADCs/PhotoElectron.

- Person assigned: Joao C.

- 4) **Drift**

- Measure the daily response of the detector. Accounts for short time scale fluctuations of the detector response(such as temperature).

- Person assigned: Nate M.

Example of web page



# Status of Far Detector(1) from Jerry Meier



- Maintenance on racks and crates, High voltage
  - Power supplies, safety, fans, filters
  - Coil checks complete
  - Replaced 1 chiller HVAC unit on surface – complete
  - FD is in running condition every day
  - No barriers to completion before beam
- SPARES STATUS
  - VARC spares good but need more repaired by PREP (sending some soon)
  - Other electronics boards supply good
  - Chip supply getting low but many stored on extra VFB's
  - Plenty of spare PMT's and bases considering low failure rate
  - PC's getting OLD but
    - replacement DAQ computers coming?
    - New power supplies bought for BRP's (should help with PVIC problems)
  - PVIC spares low but extras coming from near detector
  - PREP supplies support for LeCroix, HV cards, VARC, VMM and VFB





# Status of Far Detector(2) from Jerry Meier



- Plans for New DAQ (see Near Detector for more detail)
  - Need to run cabling (about 2000m) and install 48 port switch
  - Install another rack and smoke head for DAQ computers in computer room
  - Bill Badgett, Torretta, Hahn scheduled to visit 25 Feb for preliminary setup
- Other notes
  - Minecrew short handed (Mark Hanhardt left for Homestake)
    - Hiring process started
    - Lab working 8 hour days until replacement is hired and trained
- **Far Detector is running great!**



# Near Detector Hardware

(S. Hahn)



- Inventory of existing spares and needs (complete Excel list):
  - This has allowed us to find items with low % of spares and work on generating more
  - In some cases, this is building or filling new boards (*e.g.*, Keepers and Minders, see next slide)
  - In other cases, this is finding or fixing spares (*e.g.*, Bira 8880 AC Relay Units and Master/Minder power supply repairs at D0)
- Procedures for making spares available at detector and repairing spares in a timely fashion:
  - Most spares reside in NUMI tunnel near detector for immediate replacement
  - Spares cabinet at surface building for boards which are repaired at Argonne
- Some miscellaneous items (*e.g.*, updated laptop for HV and power supply tests and diagnosis) also generated in last year



# Details of Readout Spares



**M I N D S** ND DAQ front-end electronics in good shape for 2013:

- Keeper auxiliary board (rarely fails):
  - Gary Drake (ANL) should soon give us costs to build 5 new Keepers
  - Since small number, will do in-house at Argonne, should allow us to get new boards as soon as they're finished and tested
  - Even one doubles our spares! Six altogether more than 12% spares
- Minders (Front end):
  - Over summer, established we had inventory to fill empty MENU PCBs
  - Merle Watson (PPD) did surface mount work and testing. We now have 100 “new” MENU boards (holds QIE chips). Could make about 50 more if needed.
  - These have been taken to Argonne to fill 6 empty Minders, which will then be tested. This doubles our spares from 1% to 2% (587 Minders in detector!)
  - I've suggested we put these at the front of the replacement queue to make sure they work as spares in detector
- RPS (rack protection) airflow outlet boards:
  - Being modded (again by Merle Watson) as per Alec Habig's (Duluth) instructions to prevent race condition in RPS units on power up.

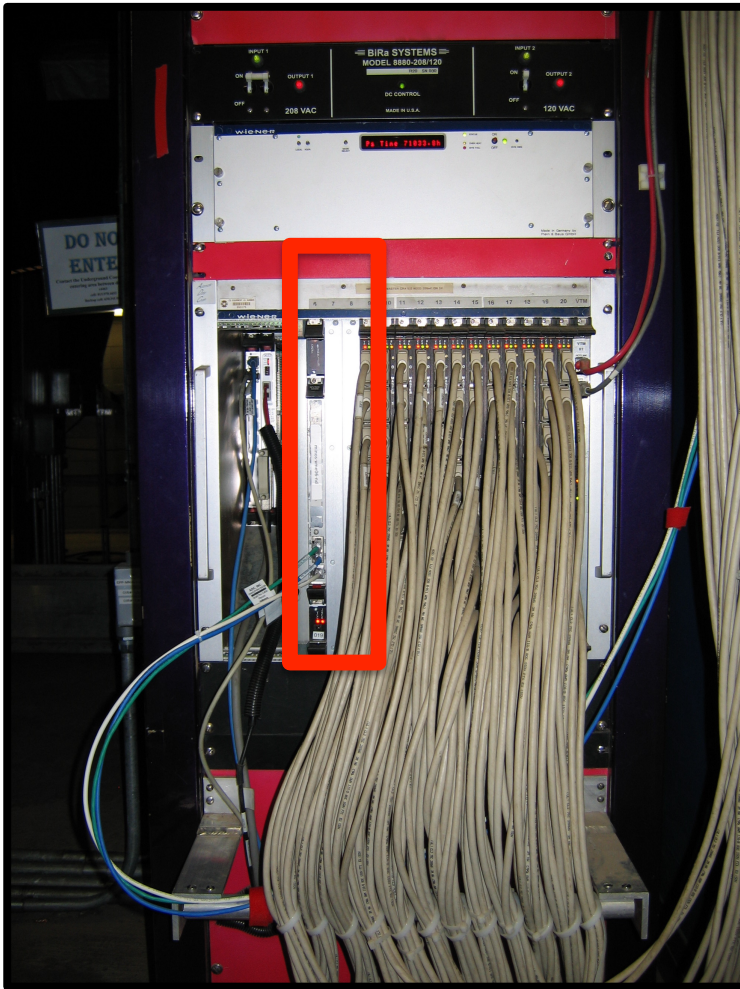


# MINOS+ ND DAQ Changes



Original System heavily dependent on parts no longer available

→ Standardize



- Front ends unchanged
- Timing rack unchanged
- Master racks:
  - Added MVME 5500 in 6U-to-9U adapter with Gigabit Ethernet, serial, and reset cables
  - Tested in all Master crates to not interfere with existing DAQ

This work was led and implemented by B. Badgett, D. Torretta, S. Hahn (PPD)

MAJOR ACCOMPLISHMENT and our thanks.

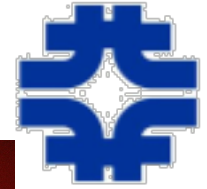




Center rack  
with door  
open:  
"refurb"  
DAQ



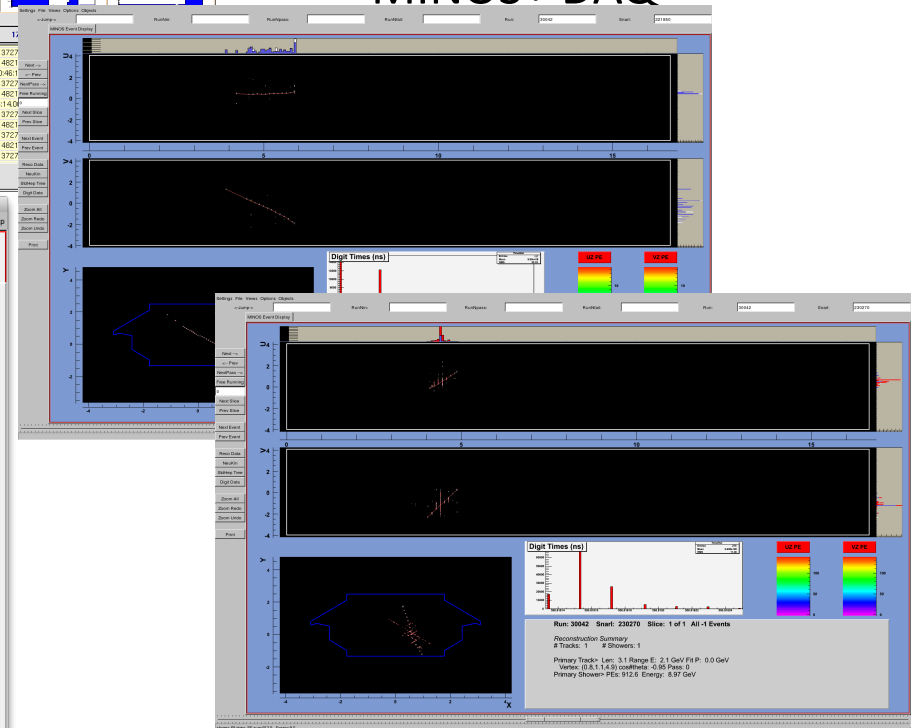
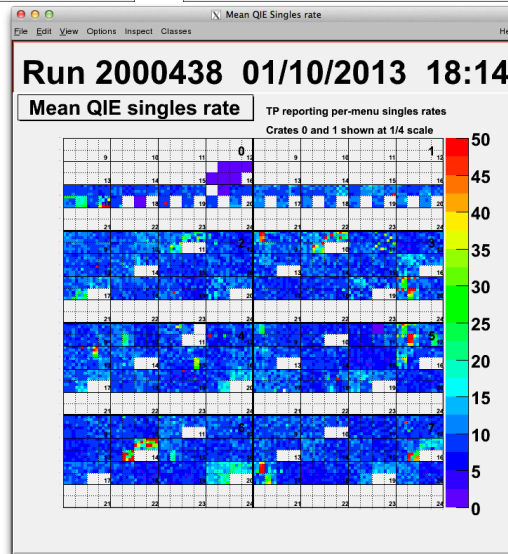
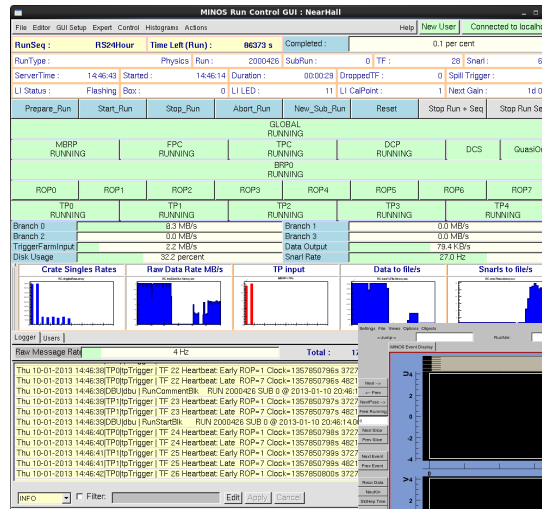
# MINOS+ ND "Refurb" DAQ



3 racks with  
grey  
computers:  
old DAQ



- 10 1U quad (2 cores x 4 processors = 8 cores apiece) computers running multiple processes replace 3 racks of dedicated computers
  - Only 4 1U computers used for DAQ; 2 gateways; remainder are spares
- This replaces 3 racks of old (circa 2002), unsupported computers and UPS's
- Simple RPS to drop power in rack if smoke detected



- MINOS ND magnet coil on since 01/30
- Event display showing typical cosmic rays with curved tracks using MINOS+ DAQ



# Underground Area Status and Support



- Underground area has become the responsibility of the PPD Intensity Frontier and Testbeam Group.
- This includes coordination with FESS and building management.
- Cooling and power have been modified and this group is expert.
- Institutional memory. S. Hahn has coordinated shutdown activities.



# Offline Processing

(Rashid Mehdiyev, Offline Coord.)



- Two streams of data processing:
- Keep-up daily processing from both detectors for calibration and data validation/quality.
- Physics quality data processing with final calibration constants
  - Usually at operational boundaries, typically few times per year.
- Cosmic data processed separately with ND pre-scaled by 1/16. MINOS does not pre-scale the ND beam data due to MINERvA needs for muon tracks.
- MC processing involves an event simulation (which usually time consuming and happens outside Fermilab), followed by an event reconstruction, that we run on the Fermigrid.
- Resources
  - 3 filled service job for production
  - 5 filled service jobs for MC
  - Open service jobs – Database manager and Release Manager + backup batch manager
  - Plan is to try to assign from collaboration, negotiating





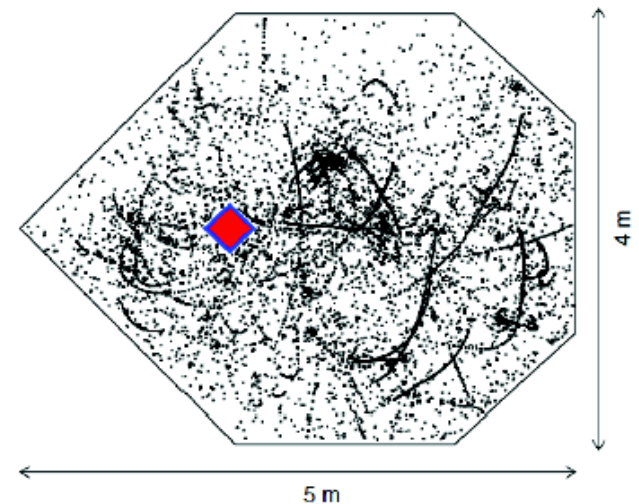
# Reconstruction

(Z. Pavlovic and L. Whitehead, Reco Coordinators)



- Reconstruction needs to be updated for higher expected event rate
- “Reconstruction” software also performs last stage of event building.
- Current status
  - Code running slower (~50-100% per event)
- Goal for beginning of the run
  - Optimize code to run ~2x faster
  - Increase parallel processing
  - Milestone: Reco workshop end March
- Future improvements
  - Improve algorithms (digit/strip, slice, track), shower
  - Possibly prescale specialized samples.
  - Retune shower/track energy resolution

*MINOS ND/Medium energy*



Tracks separated in time



# Computing Resources

- Demands relatively modest and understood
- Actually dominated by analysis jobs, not production.
- Model presented at recent computing review by A. Kreymer, CD liaison.
- Accounts for growth in various components
- Issue concerning CD goal for more tape use vs. disk. Will attempt to accommodate in model but may need some discussion.

| Resource          | 2011 | 2012 (+inc) | 2013 (+inc) | 2014 (+inc) |
|-------------------|------|-------------|-------------|-------------|
| Disk NFS TB       | 160  | 240 (+80)   | 290 (+50)   | 420 (+180)  |
| Disk Dcache TB    | 46   | 46          | 46          | 46          |
| Tape TB           | 650  | 750 (+100)  | 850 (+100)  | 916 (+90)   |
| Grid Slots        | 1000 | 1200(+200)  | 1200        | 1200        |
| Interactive Cores | 32   | 32          | 32          | 32          |
| Servers           | 6    | 4           | 2           | 2           |



# Calibration Summary

(Jeff DeJong and Ruth Toner, Calibration Coordinators)



## Raw Detector Response

Light Injection System

Linearity Correction

Atmospheric muons

Drift Correction

Atmospheric muons

Strip-to-Strip Correction

Atmospheric muons

Attenuation Correction

Stopping muons

Energy Scale Correction

Calibrated Response

## During MINOS operation(2005-2012) :

1. The Raw response of the detectors have decreased by ~10%
2. The calibrated response of the detector is temporally and spatially stable to 1%

## The calibration chain is fully automated

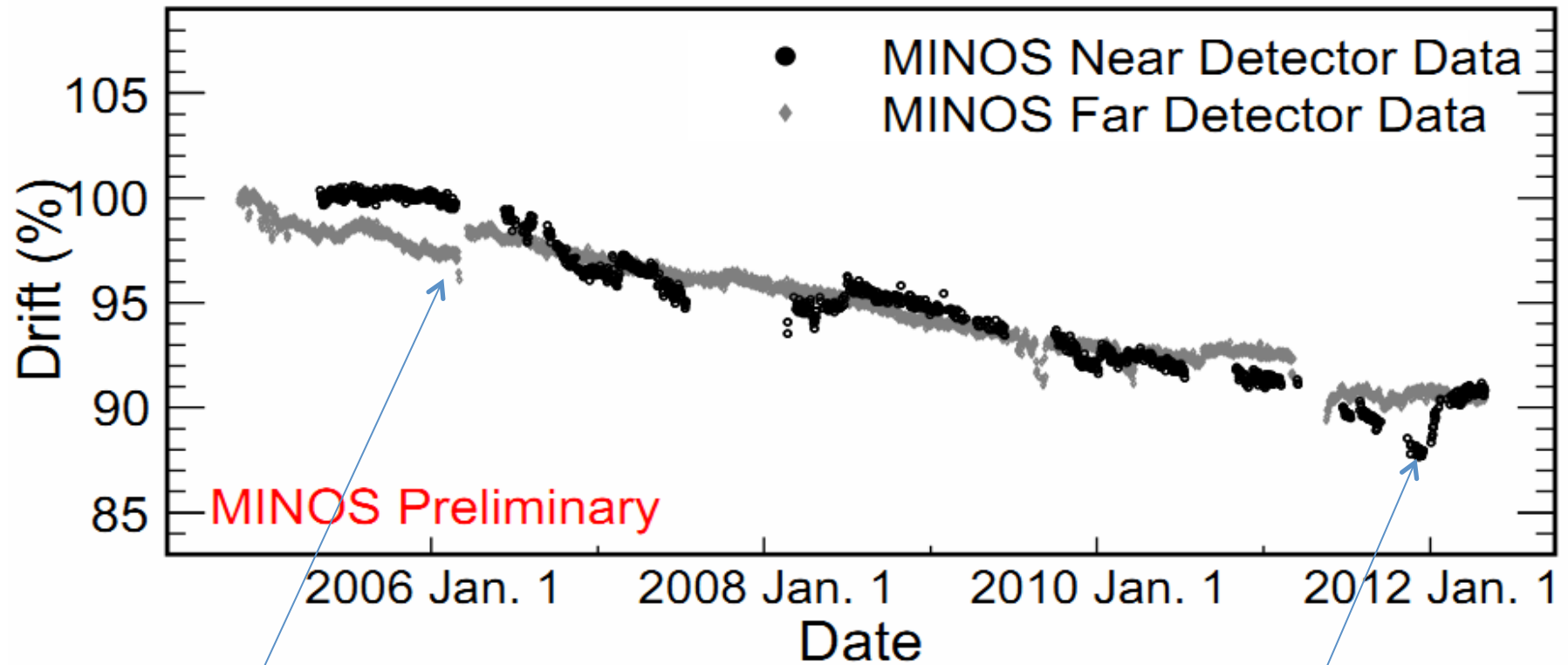
1. Detectors have recently returned to a “physics”-level state, and we are in the process of ensuring the consistency /continuity of the calibrations.

## Calibration in the MINOS+ Era

1. The calibration procedure is unchanged, although we are upgrading the attenuation calibration to obtain a flatter spatial response
2. Will need to validate calibration numbers in light of the new DAQ systems, new reconstruction, and beam intensity



# Raw Detector Response(Drift)



High Voltage retune at  
FD

New Chiller Install at the  
ND



# Shift Planning (1)

- Detectors highly reliable, many on-site experts.
  - Shift focus of shift to performance monitoring
  - Defined and staffed service job:
    - Use a web page model similar to MINERvA to display necessary shift plots and their references. Keep track of the reference plots and make sure they are current.
    - Responsible – Goias, Brazil
- Shift scheduling tools – will use ECL based planner
  - “User Evaluation” by Sao Paolo collaborator.
    - Basically outstanding tool
    - Some requests to CD will be generated for needed features
  - Defined service task: Shift coordinator
    - Removes burden from Run Coordinator
    - Responsible – Sao Paolo (Gouffon)



# Shift Planning (2)



- Current Shift plan – begin 8 x 7 coverage 1 May
  - Day shifts
- Go to 16x7 1 June
- After appropriate interval (probably about one month) move to one shift per day.
  - Any shift as long as 8 hour coverage.
- This maximizes collab. resources
  - NOvA will be primary for beam.
  - MINERvA has expertise in near detector checks too.
  - Far Detector has 10 x 5 coverage at Souan in addition.
- Strongly encouraging remote shifts
  - Demonstrated in last run
  - Working with directorate, AD for protocols. 90% complete.
  - Defined and staffed service job:
    - Discuss with collaborators requirements for remote shifting. Make sure they have the required hardware and know what software is needed. Certify remote shift locations.
    - Responsible: Goias



# Control Room Status

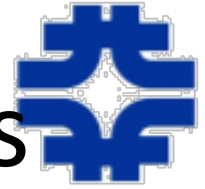
(Art Kreymer)



- No plans for XOC right now, will be in 12NW.
- Hardware installation
  - Four new computers are in use, decommissioning older.
  - Will move the detector control system underground soon, removing the need for DAQ/DCS networking in WH12NW.
- Software configuration
  - Run Control has been updated for the new DAQ.
  - Removing the last use of AFS this month.
  - Cesar Castromonte is improving the Online Monitoring plots. (defined service task)
  - Moving most web services to CS servers this month.
  - Any that remain should be restricted to Fermilab.
- Evaluating the new Fermicloud based event display ariadne-minos.
-



# Inter-Experiment Expectations



- We anticipate NOvA to be on shift 24/7
- We anticipate MINERvA will continue to look at MINOS ND when on shift.
- We have appreciated help from MINERvA on routine maintenance of ND electronics.
  - MINOS support has been Fermilab staff scientists, and visiting students and postdocs.
  - Exact model for this run under discussion with PPD and MINERvA
- Protocols for remote shifts of the experiments will be coordinated among Run Coordinators, using agreement from Program Planning.





# Beam Monitoring Status



- AD archives beam data.
- MINOS online monitor has been “JAS” (Java Analysis Studio) application.
- Intensity Frontier beam database archives beam conditions for offline systematics studies.
  - NEW PRODUCT – thanks to A. Norman of NOvA.
- Some devices also go into MINOS Calib DB for offline. Current plan keeps this.
- Online monitoring plan is to
  - i) Reconfigure JAS for new database (South Carolina with some BNL help).
  - ii) In parallel work with NOvA to evaluate web-based product from Computing Division.



# Laboratory Support



- Throughout this talk, it should be clear that lab support has been crucial for preparations, especially
  - Particle physics division
    - IF and Testbeam Support Dept.
      - Steve Hahn (run coordinator and shutdown coordinator)
      - Aria Soha ( underground areas)
    - PPD/EED/Online Support.
      - Bill Badgett, Donatella Torretta
    - Most recently Torretta to be Run Coordinator during Commisioning.
  - Computing Division
    - Kreymer, Robert Hatcher, others
  - FNAL postdocs
    - Currently one senior postdoc (Pahlka), one joining (Kiveni)
    - Request a third postdoc to spread service load.
  - Concern that people get promoted to larger responsibilities without filling their current roles.
    - Reflects expansion of Intensity Frontier
    - Collaboration can help but not all these roles are well-matched to collaborators
  - **RUNNING EXPERIMENTS NEED TO REMAIN LAB PRIORITY**



# Conclusions and Needs



- MINOS+ will be in good condition to begin commissioning with beam
- Detectors robust and running
- Analysis needs being addressed by collaboration.
- Most service positions filled
- Excellent support from lab, but ongoing concern.



Backup

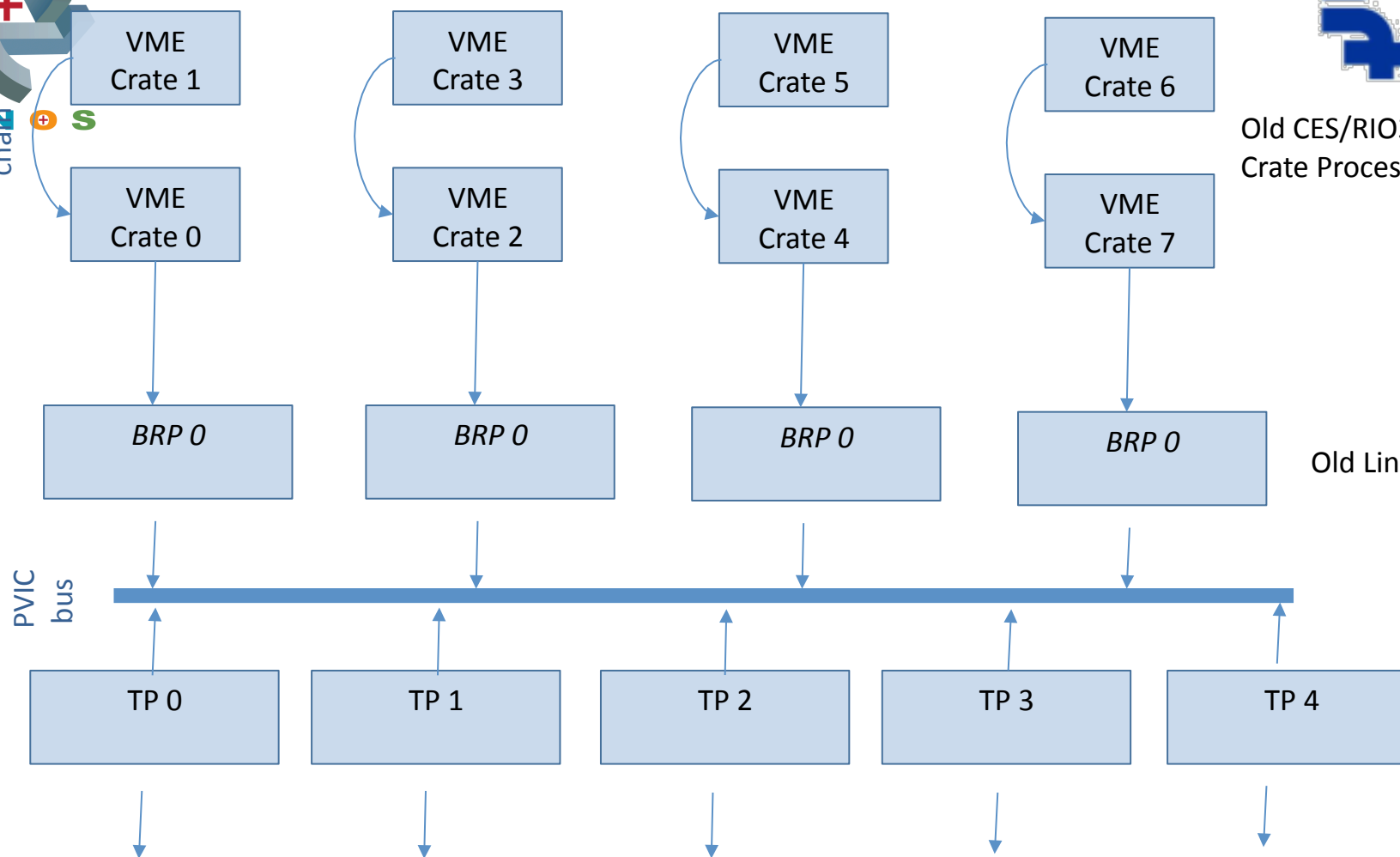




# Original Minos Event Builder



Old CES/RIO3 VME  
Crate Processors



*Off to data logger, monitors and control on normal 100Mb ethernet*

BRP = Branch Processor

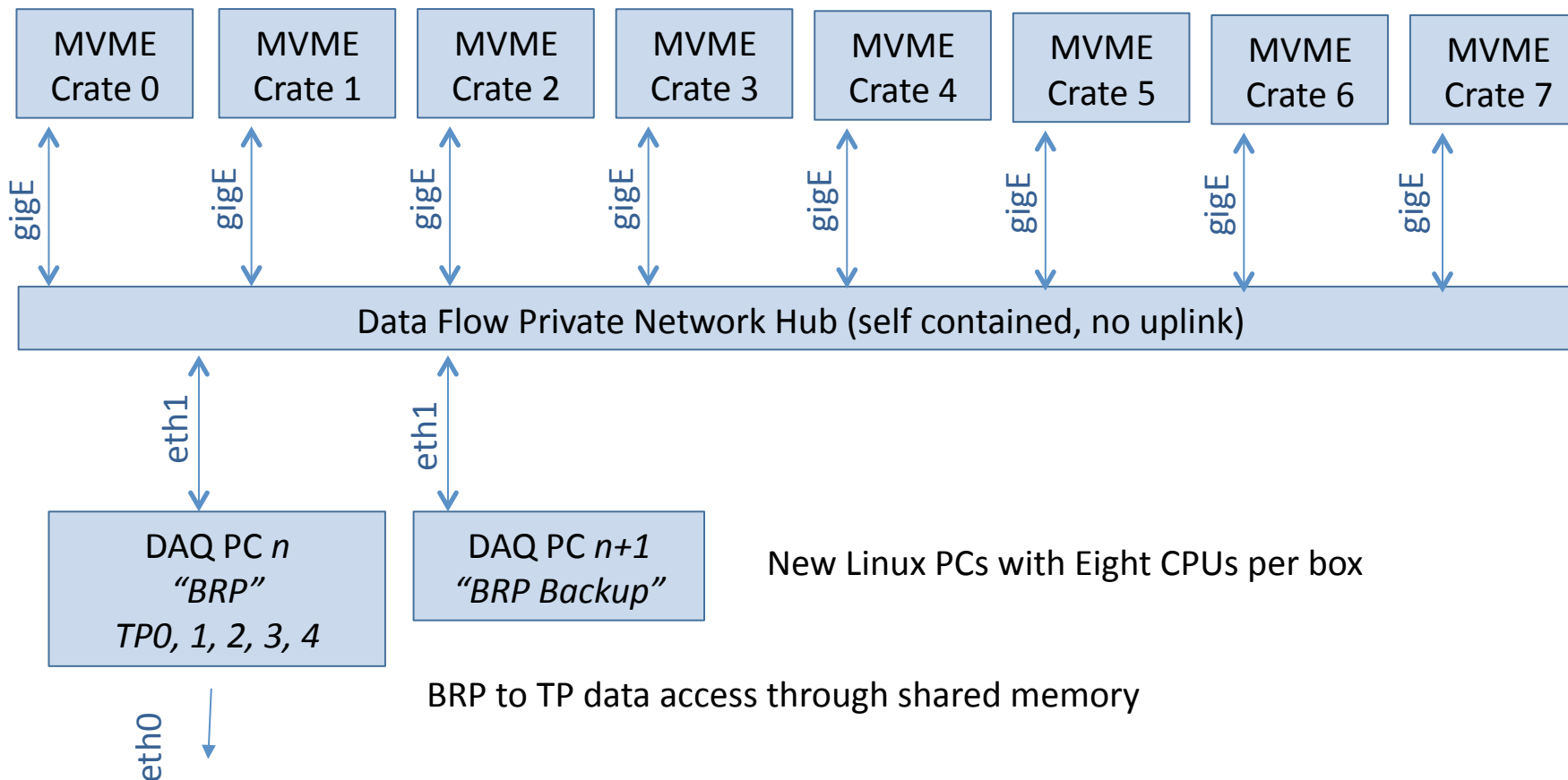
TP = Trigger Processor



# New Minos+ Event Builder 2012



New MVME 5500s  
Readout Processors



*Off to data logger, monitors and control on other new PCs with 1Gb ethernet*

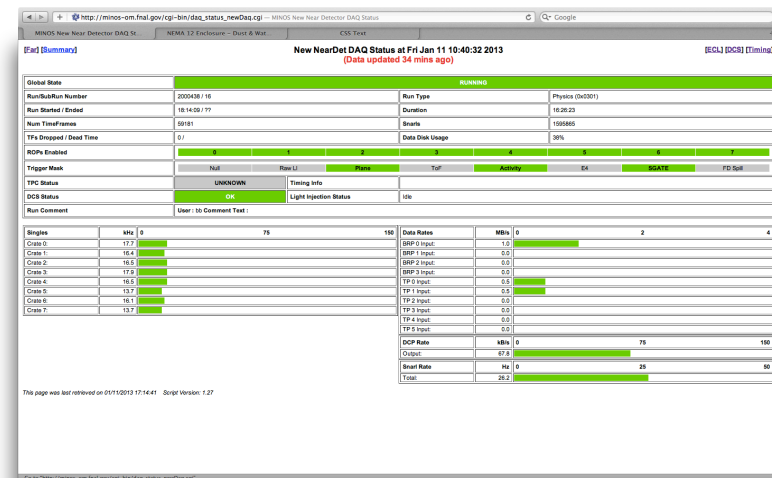
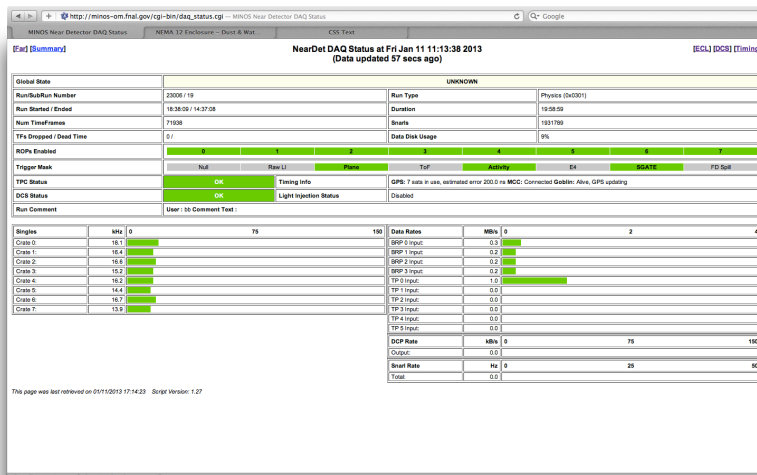


# MINOS+ ND “Refurb” DAQ



- On MINOS control room page, can see status of both old MINOS DAQ and new MINOS+ DAQ

[Near Detector Status](#)  
[MINOS DAQ status page](#)  
[MINOS+ DAQ status page](#) **NEW**  
[DCS status page](#)  
[Timing status page](#)  
[Data Quality page](#)



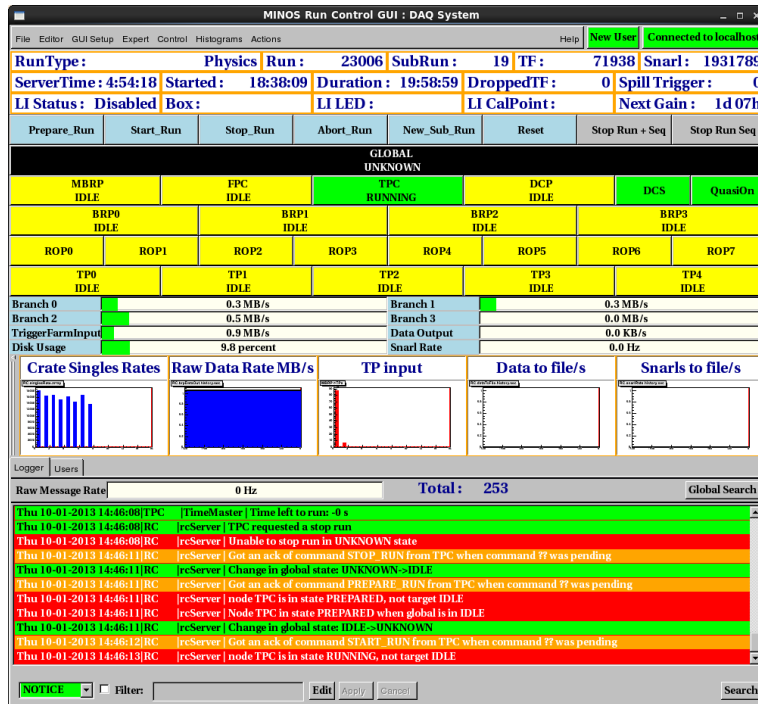


# MINOS+ ND “Refurb” DAQ

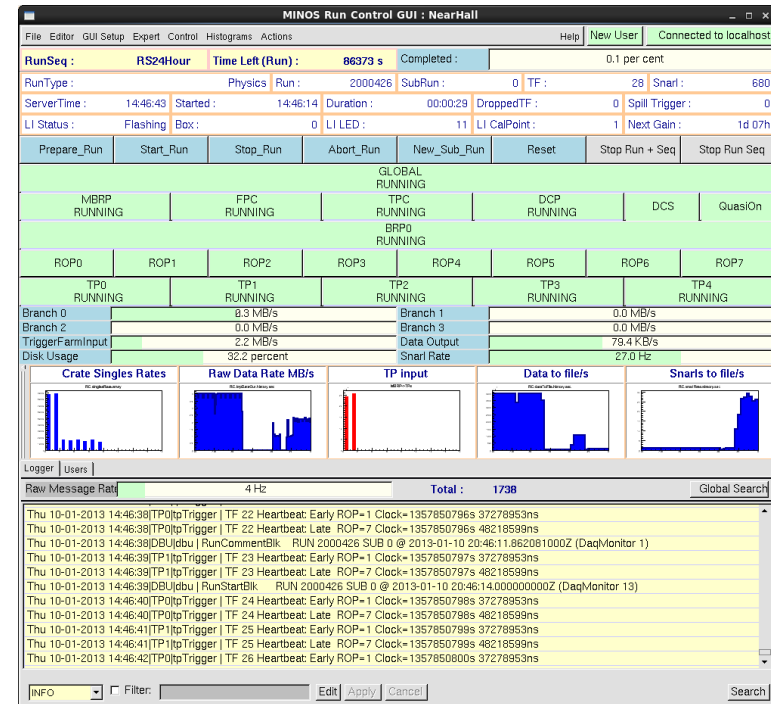


MINOS

- Trying to catch places we can improve user experience
- Example: make rcGUI more readable

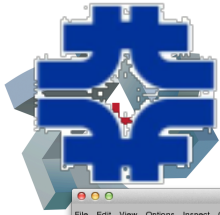


MINOS DAQ rcGUI



MINOS+ DAQ “rcPastel”

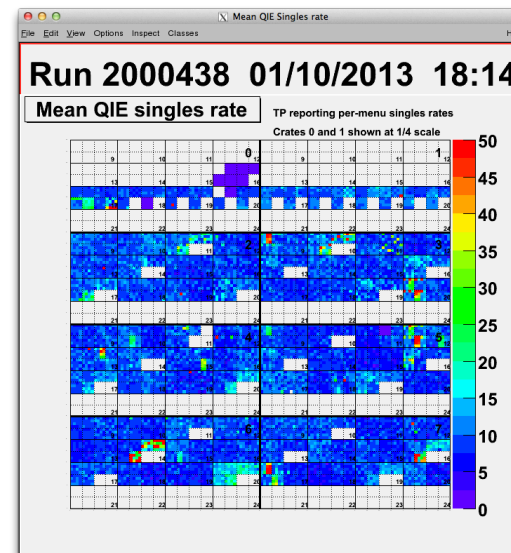
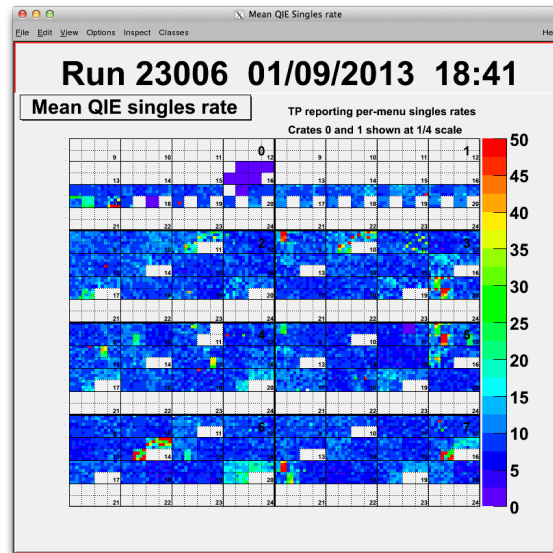
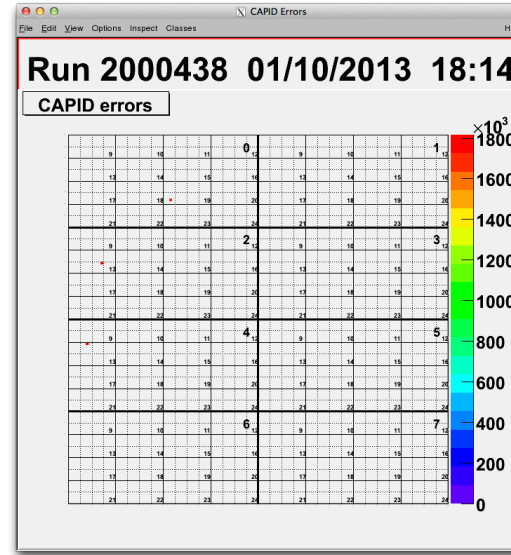
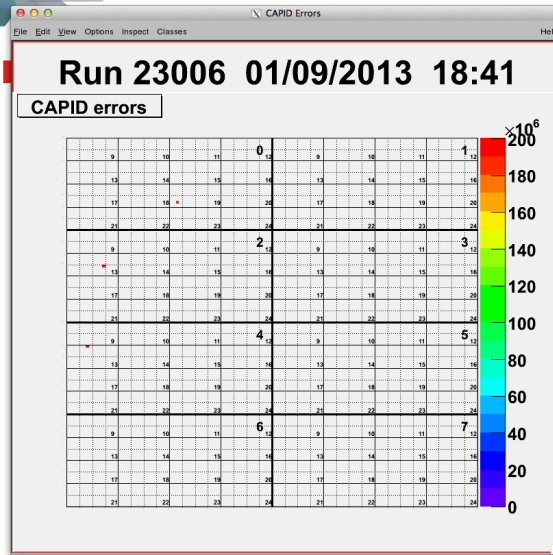




# MINOS+ ND “Refurb” DAQ



M



- Online monitoring “checklist” plots:
  - MINOS DAQ on left, MINOS+ DAQ on right (note 2000xxx run number)
  - 3 bad QIE channels, do you see them?
  - Mean QIE singles rate looks pretty much identical in both
  - Have looked through all checklist plots and found no inconsistencies



# MINOS+ ND “Refurb” DAQ



• Verifying new DAQ data is OK:

- Currently taking a week of cosmics with new DAQ
- Then a week of cosmics with old DAQ
- Will have online, calibration, and DQM groups check consistency between two data sets
- Will need to maintain old DAQ to test tracking old vs. new with beam
- Will repeat the above comparison (new vs. old) with beam data to check both tracking and triggering



# MINOS Calibration Procedure



## M I Raw Detector Response

Light Injection System

Linearity Correction

Atmospheric muons

Drift Correction

Atmospheric muons

Strip-to-Strip Correction

Atmospheric muons

Attenuation Correction

Stopping muons

Energy Scale Correction

Calibrated Response

The MINOS calibration procedure is meant to ensure that for a given energy deposition  $Q_{raw}$ , the calorimetric response  $Q_{corr}$  looks the same in space/strip ( $s$ ), time( $t$ ) and in the different detectors( $d$ )

$$Q_{raw} = Q_{corr} \cdot L(Q_{raw}, d, s, t) \cdot D(d, t) \cdot A(d, s) \cdot S(d, s, t) \cdot M(d)$$

**L:** The PMT response becomes non-linear at  $\sim 100$  photo-electrons. A dedicated light injection system measures the PMT response over a wide range of light levels at least once a month.

**D:** The drift calibration measured daily corrects for the combined *time and temperature* dependencies of *all* the detector components at each detector.

**S:** The strip to strip calibration removes the channel-by-channel differences accounting for such effects as light yield, read out fiber length and PMT pixel gains.

**A:** The attenuation calibration corrects for the light lost travelling through the wavelength shifting fibers from the point of production to the end of the scintillator module.

**M:** Stopping muons deposit a known amount of energy. These muons are used to link the post-calibration energy scales at each detector.



# Calibration Summary



**During MINOS operation(2005-2012) the:**

1. The Raw response of the detectors have decreased by ~10%
  - The Gains of the PMTs have increased by ~20%
  - The Light Level incident on the PMT has decreased by 25%
2. The calibrated response of the detector is temporally and spatially stable to 1%

## **The calibration chain is fully automated**

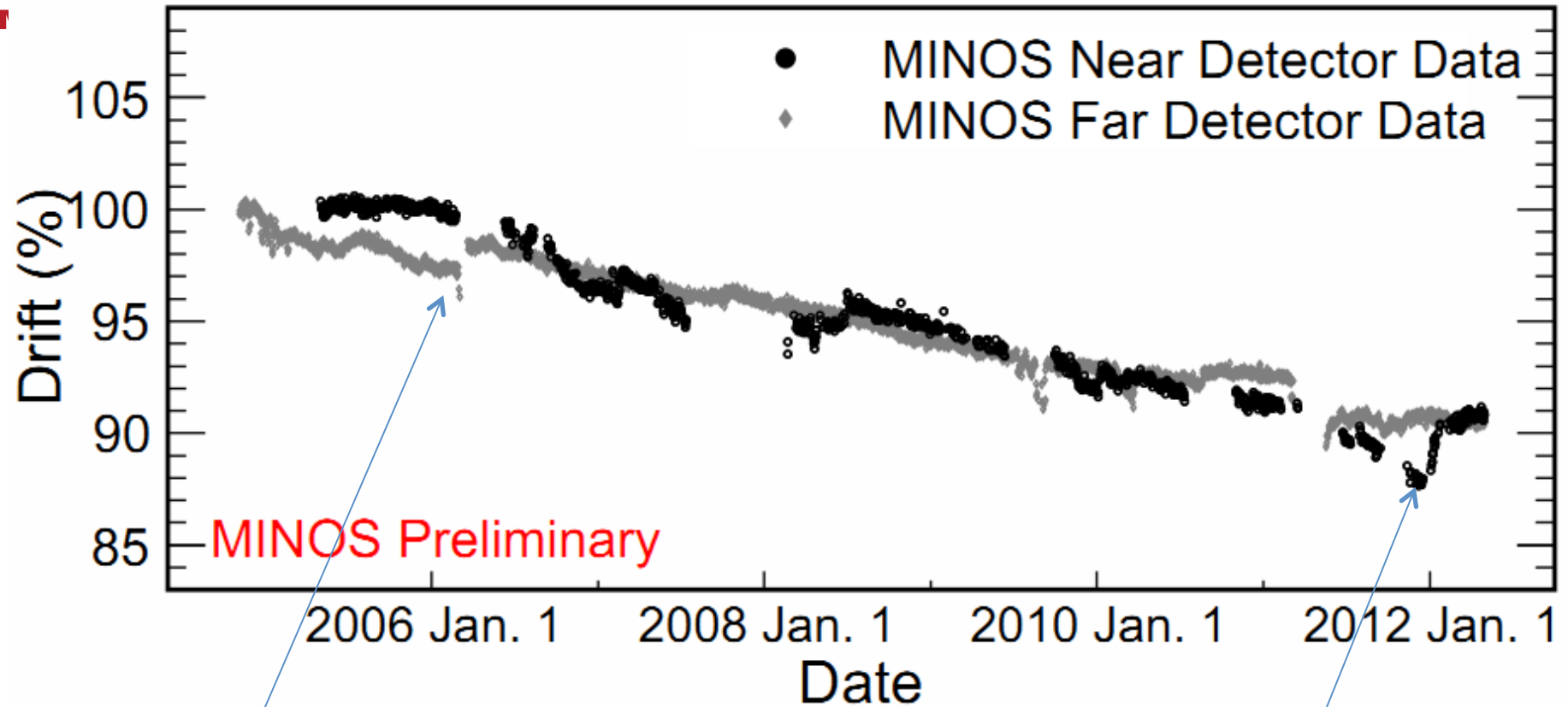
1. However, linearity, Drift and Strip to Strip have been off during the shut down due to lack of stability in the state of the detector
2. Detectors have recently returned to a “physics”-level state, and we are in the process of ensuring the consistency /continuity of the calibrations.

## **Calibration in the MINOS+ Era**

1. The calibration procedure is unchanged, although we are upgrading the attenuation calibration to obtain a flatter spatial response
2. Will need to validate calibration numbers in light of the new DAQ systems, new reconstruction, and beam intensity
  1. Biggest issue: Are the cosmic and spill energy scales still the same in Near Detector where neutrino pileup is significant?
3. We will upgrade the attenuation package to obtain a flatter spatial response



# Raw Detector Response(Drift)

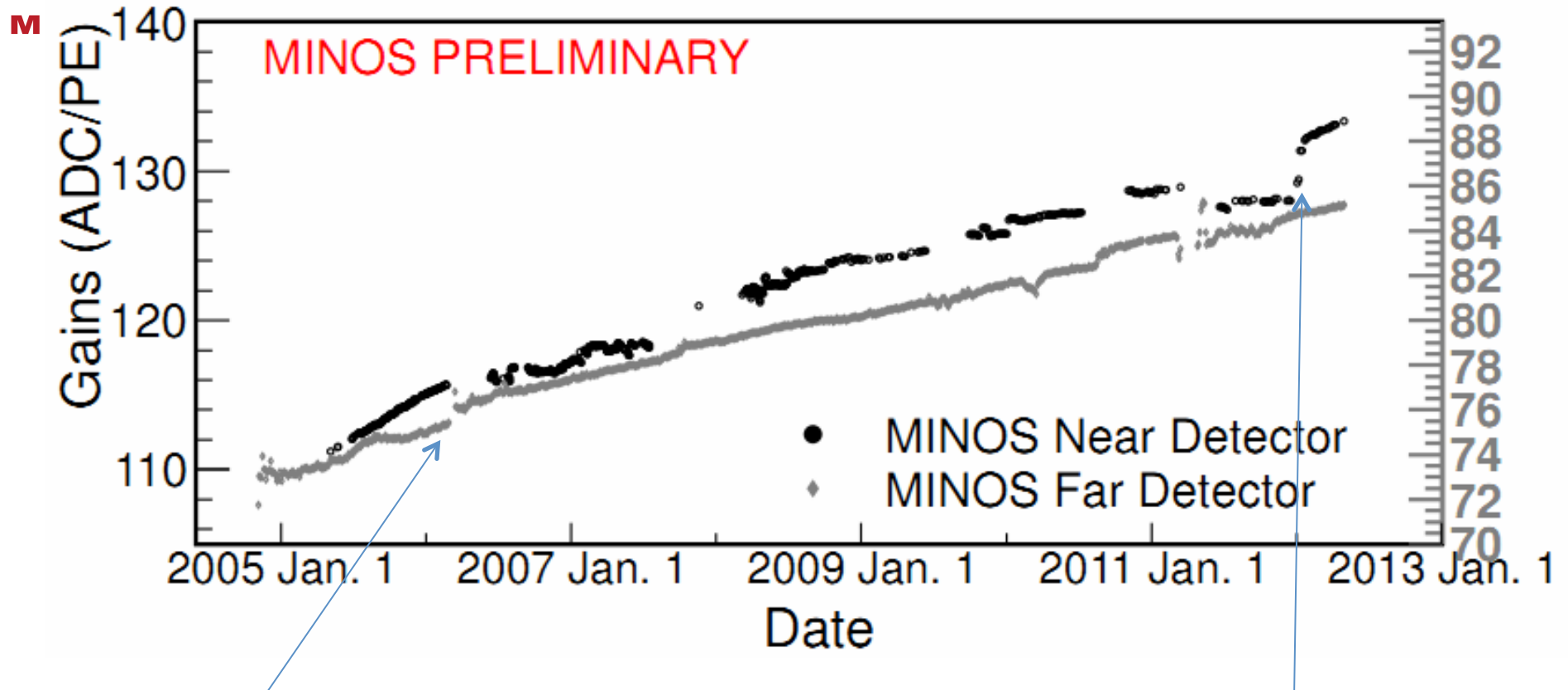


High Voltage retune at FD

New Chiller Install at the ND



# Gains of the PMTs

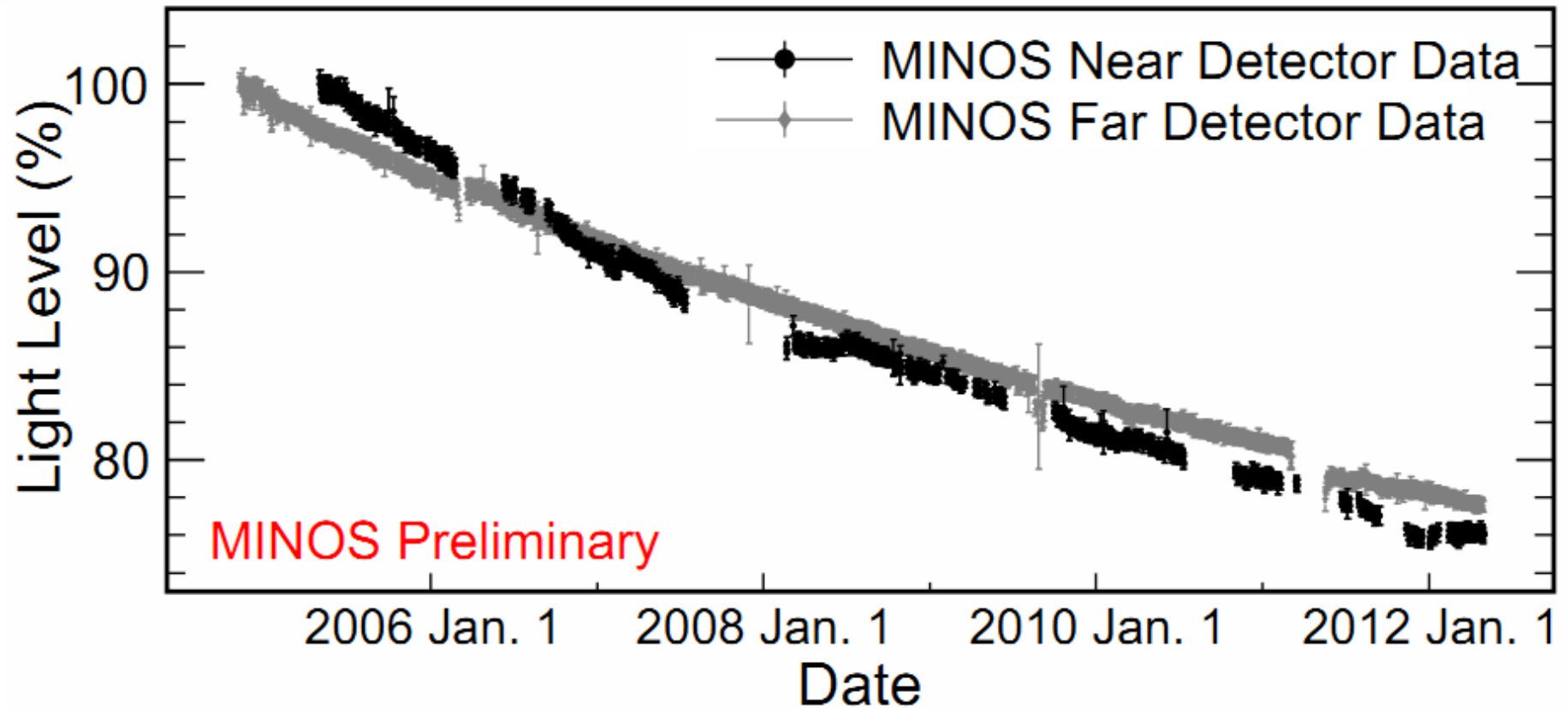


High Voltage retune at FD

New Chiller Install at the ND



# Detector Light Level(Drift/Gain)





# MINOS Calibration Stability



**M** The stability of the calibration procedure is cross-checked on a monthly basis.

The Far Detector Response to stopping-muons is stable in time to within 1.5%

The Near Detector Response to stopping-muons is stable in time to within 0.5%

The monthly fluctuations are mostly statistical, but there are a few systematic outliers.

